Assessing and Adapting to Climate Change A Look at Two of the Climate Change Science Program's Latest Products

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The Climate Change Science Program (CCSP) recently released two Synthesis and Assessment Products, which compiled research from over 1000 publications to assess "The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States" (SAP 4.3), and SAP 4.4, which is a "Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources." This article highlights key points from SAP 4.3 and SAP 4.4, focusing on information that is important to water managers in the West.

Background

The Climate Change Science Program (CCSP) was created in 2002 to improve government-wide management of climate science and climate-related technology development. The CCSP integrates President Bush's Climate Change Research Initiative (CCRI) with the U.S. Global Change Research Program (USGCRP). The CCRI addresses issues related to uncertainty in global climate change science and the USGCRP supports research on the interactions of natural and human-induced changes in the global environment. The integration of these two organizations allows the CCSP to provide reliable climate information to policy makers so that they can make judgments and decisions about adapting to and mitigating climate change.

To support its mission, the CCSP coordinates and distributes Synthesis and Assessment Products (SAPs) specific to its five distinct goals (Table 1). Each SAP undergoes a peer review process as required by the Information Quality Act (IQA) for highly influential documents. So far, the CCSP has released eight final reports and plans to complete 13 more by September 2008, and more over time. The two most recent products, SAP 4.3 and SAP 4.4, support the CCSP's fourth goal of understanding the sensitivity and adaptability of ecosystems to climate change.

Synthesis and Assessment Products 4.3 and 4.4

Released in May 2008, SAP 4.3 assesses the potential impacts of climate change on U.S. land resources, water resources, agriculture, and biodiversity (hereafter referred to as the 'resources report.') The SAP 4.3 project was led and coordinated by the National Center for Atmospheric Research (NCAR) and sponsored by the U.S. Department of Agriculture (USDA). The report also examines whether current observed changes within these realms can be attributed in whole or part to climate change (4.3, p. vii). The CCSP released SAP 4.4 in June 2008 as a follow up to SAP 4.3 by presenting potential steps for adapting to climate change. SAP 4.4 (hereafter referred to as the "adaptation report,") provides information on adaptation options for climate sensitive ecosystems and resources such as national forests, national parks, and wild and scenic rivers, but is broadly applicable to many types of ecosystems (4.4, p. xviii). Because of limited information and understanding, the adaptation report does not include the cost and benefits of implementing adaptation options, yet works to assess the confidence and integrity behind each adaptation option (4.4, p. xix).

The authors of these synthesis products made an effort to use consistent terms when describing their confidence and conclusions throughout the reports (Figure 1a). The terms were agreed upon by the CCSP agencies and reflect the judgment of the reports' authors.

A Changing Climate, Especially in the West

According to the report on resources, "there is a robust scientific consensus that human-induced climate change is occurring" due to fossil fuel burning and deforestation (4.3, p.2). Over the last century, the global-average surface temperature has increased by about 0.6 °C and global precipitation over land increased about 2 percent (Figure 1b, 4.3, p.2). Temperature and precipitation records in the U.S. are consistent with these trends as the country, overall, became warmer and wetter during the 20th century (4.3, p.2). For most of the U.S., the increased precipitation helped minimize the impacts of the warming. However, the West experienced decreased precipitation, which together with increased temperatures, has strained the region's water supply.

A limited water supply makes the western region highly sensitive to changes in precipitation and temperature (4.3, 129). Recent studies of the West indicate both a decrease in the snow water equivalent of the snowpack from 1915–2003 and an earlier trend in spring snowmelt from 1948–2002 (Figure 1c, 4.3, p. 130) . Higher temperatures in the winter months are decreasing the mountain snowpack by causing more precipitation to fall as rain rather than snow. Warming has also led to earlier spring snowmelts as temperatures become warm enough for snow to melt much sooner in the year. These rising temperatures have exacerbated the effects of decreased precipitation by increasing evaporation, which in turn increases outdoor water demand.

Recent research also found that the variability of April–September streamflow has been increasing across the western U.S. since 1980 (4.3, p.130), which is a concern for water managers. Current methods for water management are based on the concept of statistical stationarity, meaning they assume that the probability distribution of observations does not change with time (4.3, p.121). However, "the reliance on past conditions as the foundation for current and future planning and practice will no longer be tenable as climate change

SAP Product #	Scheduled Completion Date	Topic
Goal 1: Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and change		
1.1	COMPLETED May-06	Temperature trends in the lower atmosphere: steps for understanding and reconciling differences
		http://www.climatescience.gov/Library/sap/sap1-1/finalreport/sap1-1-final-all.pdf
1.2	Sep-08	Past climate variability and change in the arctic and at high latitudes
1.3	Sep-08	Re-analyses of historical climate data for key atmospheric features, Implications for attribution of causes of observed change
Goal 2: Improve quantification of the forces bringing about changes in the Earth's climate and related systems		
2.1	COMPLETED Oct-07	Scenarios of greenhousegas emissions and atmospheric concentrations and review of integrated scenario development and application
		http://www.climatescience.gov/Library/sap/sap2-1/finalreport/sap2-1a-final-all.pdf
		http://www.climatescience.gov/Library/sap/sap2-1/finalreport/sap2-1b-final-all.pdf
2.2	COMPLETED Nov-07	North American carbon budget and implications for the global carbon cycle
		http://www.climatescience.gov/Library/sap/sap2-2/final-report/sap2-2-final-all.pdf
2.3	Oct-08	Aerosol properties and their impacts on climate
2.4	Aug-08	Trends in emissions of ozone-depleting substances, ozone layer recovery, and implications for ultraviolet radiation exposure
Goal 3: Reduce uncertainty in projections of how the Earth's climate and environmental systems may change in the future		
3.1	Jul-08	Climate change models: assessment of strengths and limitations
3.2	Jul-08	Climate projections for research and assessment based on emissions scenarios developed through the CCTP
3.3	COMPLETED Jun-08	Weather and climate extremes in a changing climate. Regions of focus: North America
		http://downloads.climatescience.gov/sap/sap3-3/sap3-3-final-all.pdf
3.4	Sep-08	Abrupt climate change
Goal 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes		
4.1	Aug-08	Coastal elevation and sensitivity to sea level rise
4.2	Sep-08	Thresholds of change in ecosystems
4.3	COMPLETED May-08	The effects of climate change on agriculture, biodiversity, land, and water resources
		http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm
4.4	COMPLETED May-08	Preliminary review of adaptation options for climate-sensitive ecosystems and resources
		http://downloads.climatescience.gov/sap/sap4-4/sap4-4-final-report-all.pdf
4.5	COMPLETED Oct-07	Effects of climate change on energy production and use in the United States
		http://www.climatescience.gov/Library/sap/sap4-3/final-report/default.htm
4.6	Jun-08	Analyses of the effects of global change on human health and welfare and human systems
4.7	COMPLETED Mar-08	Impacts of climate change and variability on transportation systems and infrastructure: Gulf Coast study
		http://www.climatescience.gov/Library/sap/sap4-7/final-report/sap4-7-final-all.pdf
Goal 5: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change		
5.1	Jul-08	Uses and limitations of observations, data, forecasts, and other projections in decision support for selected sectors and regions
5.2	Sep-08	Best practice approaches for characterizing, communicating, and incorporating scientific uncertainty in decisionmaking

Table 1: A comprehensive list, taken from the CCSP website, of the CCSP's five goals and the Synthesis and Assessment Products (SAPs) pertaining to each goal.

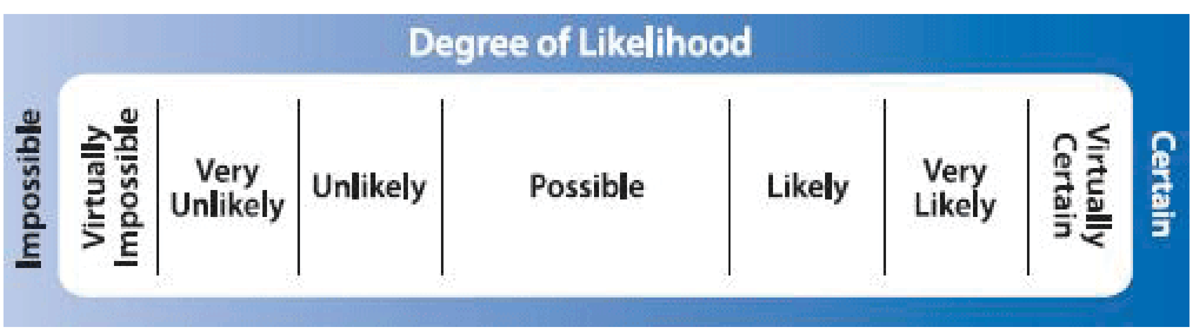

Figure 1a: Consistent language used to describe the confidence in findings and conclusions throughout the reports (4.3, p. 2).

and variability increasingly create conditions well outside of historical parameters and erode predictability" (4.3, p.8). Therefore, "management of western reservoir systems is very likely to become more challenging as runoff patterns continue to change" (4.3, p.192).

Future Projections

Trends toward reduced mountain snowpack and earlier spring snowmelt runoff peaks in the West are very likely to continue, as the Intergovernmental Panel on Climate Change (IPCC) projects the global average temperature will rise another 1.1 to 5.4°C by 2100 (4.3, p.2 and 149). Substantial decreases in annual runoff are expected for the Interior West, including the Colorado River Basin and the Great Basin (Figure 1d). "It is very likely that the magnitude and frequency of ecosystem changes will continue to increase" during the next 25 to 50 years, possibly accelerating in the future (4.3, p.3). These changes will have significant impacts

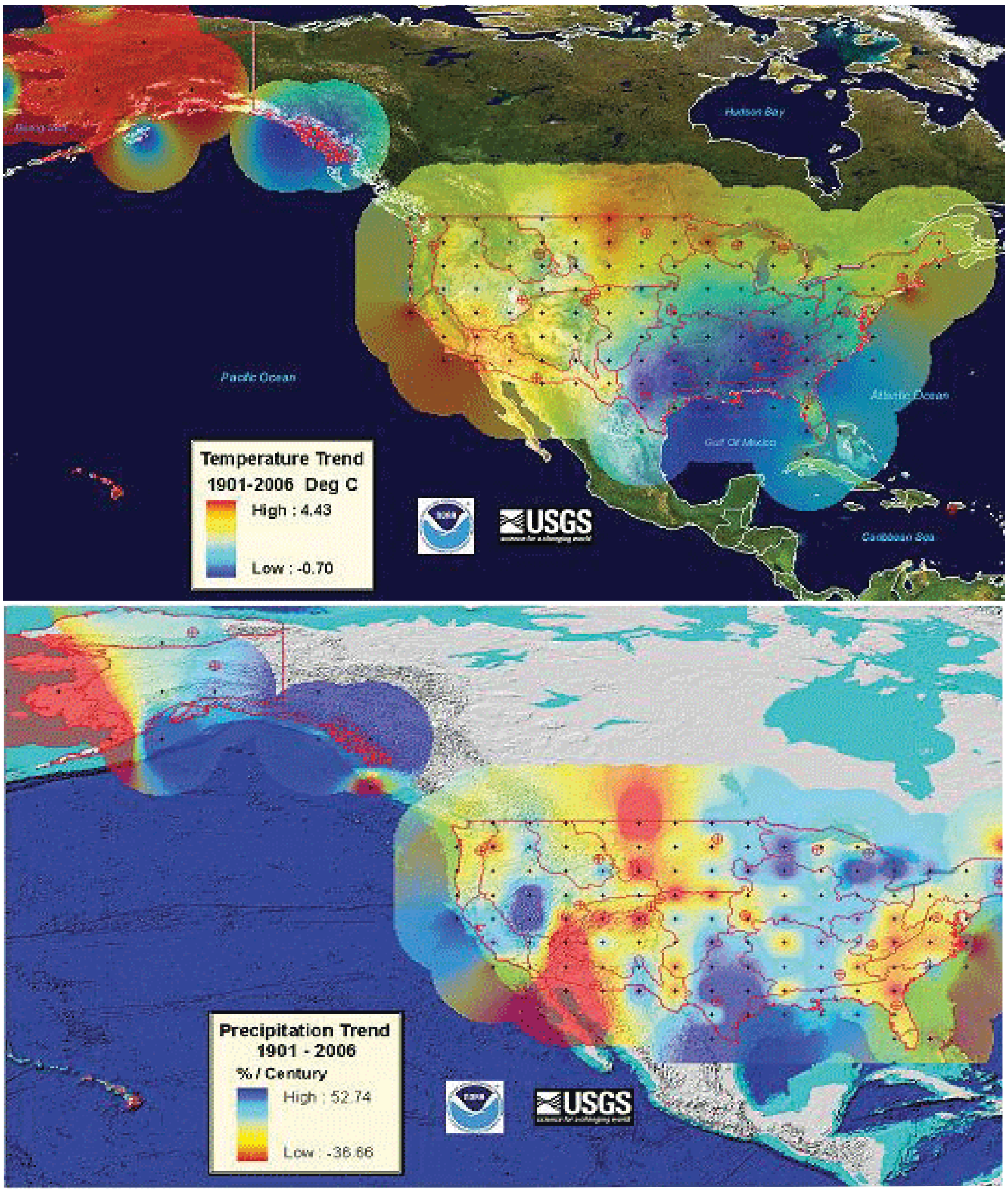

Figure 1b: U.S. temperature (upper) and precipitation (lower) trends from 1901–2006. Temperature data are averaged from weather stations across the country. Precipitation changes are shown as a percentage from the long-term average. Graphics courtesy of NOAA's National Climate Data Center and the U.S. Geological Survey (4.3, p. 16).

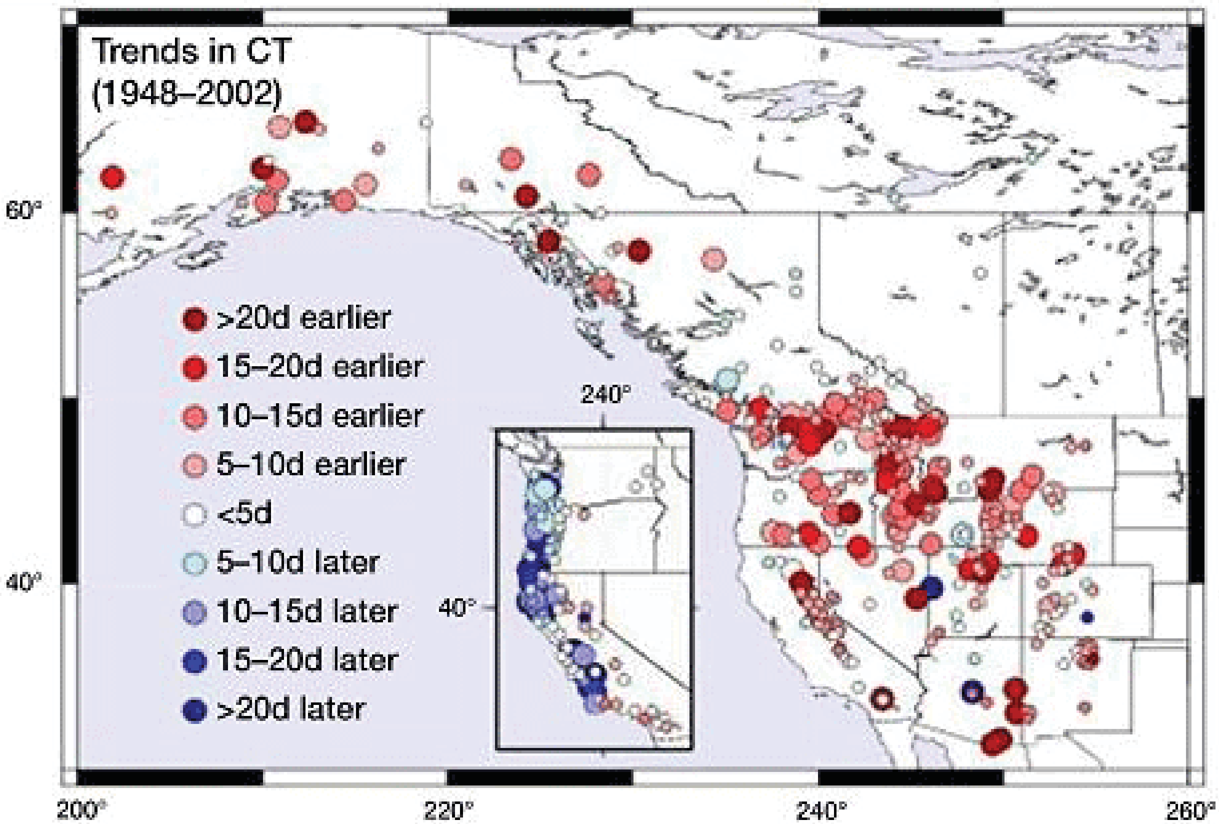

Figure 1c: Changes in western U.S. snowmelt runoff timing from 1948–2002. Source: Stewart et al. (2005) (4.3, p.131).

on U.S. hydrological systems.

A large-scale implication of projected climate change is the degradation of water quality throughout the U.S., as warmer temperatures reduce suitable habitats for cold-water and cool-water fish and enhance algal production in lakes (4.3, p.142). Climate change may also increase the intensity of storm events, implying an increase of nutrient runoff into lakes from storm-related erosion (4.3, p.142). Reduced streamflows in the West resulting from a warmer and drier climate will reduce the flushing rate, also increasing the concentration of nutrients within water sources (4.3, p.143).

The effects of climate change will extend beyond water resources as all ecosystems are sensitive to climate variations (4.3, p.121). Since 1985, there has been a decrease in growth of the semi-arid forests in the Southwest because of drought caused by warmer temperatures (4.3, p. 145). Earlier snowmelts, longer growing seasons and increased summer temperatures have been linked to an increase of wildfire activity in the western U.S. (4.3, p.146). Warmer temperatures also encourage the survival of insects, which promotes forest insect epidemics (4.3, p.146).

Where to Go From Here: Assessment and Adaptation

A key step in preparing for climate change is accurately assessing the situation – a task that may be difficult to do with our current hydrologic system. According to the resources report, "essentially no aspect of the current hydrologic observing system was designed to detect climate change or its effects on water resources" and "as a result, many of the data are fragmented, poorly integrated, and unable to meet the predictive challenges of a rapidly changing climate" (4.3, p.146). Improvements within those observing systems could increase the understanding of past hydroclimate changes and increase the ability to interpret the potential effects of future changes (4.3, p.146). Suggested improvements include an increase in the number of streamflow observation stations, continued improvements in the measurement of actual evaporation, and increased support for a core network of soil moisture monitoring stations (4.3, p. 146).

"While there will always be uncertainties associated with

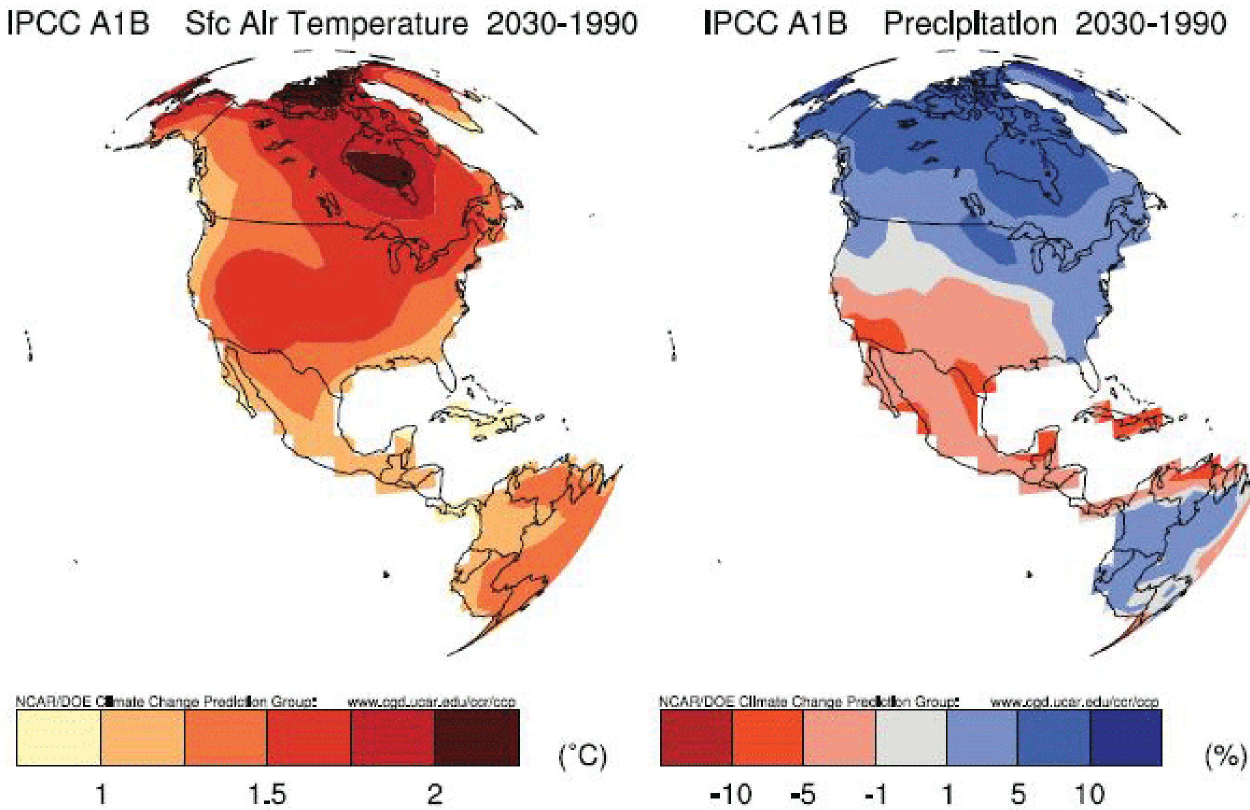

Figure 1d: Projected changes in U.S. temperature (left) and precipitation (right) by 2030 if atmospheric concentration of greenhouse gases increases to about 700 parts per million (roughly double the pre-industrial level). The changes are shown as the difference between two 20-year averages (2020–2040 minus 1980–1999). These results are based on simulations from nine different climate models from the IPCC AR4 multi-model ensemble. The simulations were created on supercomputers at research centers in France, Japan, Russia, and the United States (4.3, p.17).

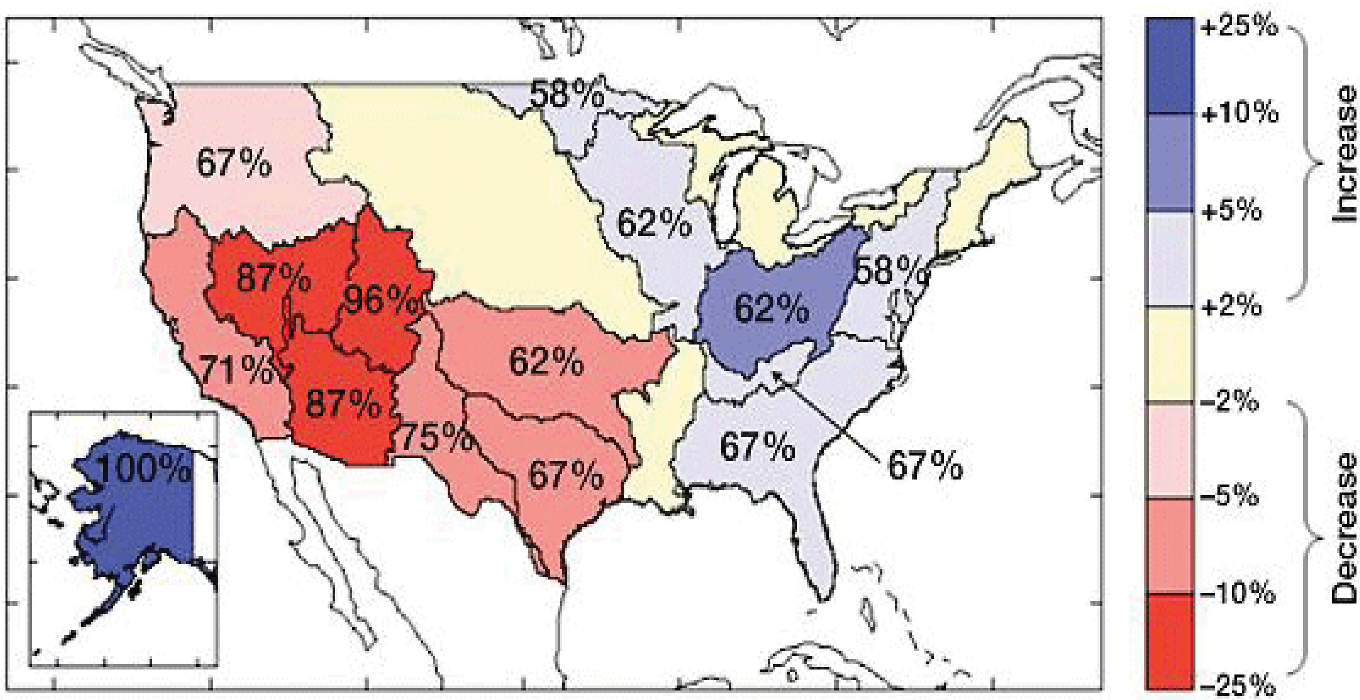

Figure 1e. Projected changes in median runoff interpolated to U.S. Geological Survey (USGS) water resources regions from 24 pairs of global climate model (GCM) simulations for 2041–2060 relative to 1901–1970. Percentages are fraction of 24 runs for which differences had same sign as the 24-run median. Results replotted from Milly et al. (2005) (4.3, p. 138).

the future path of climate change the response of ecosystems to climate impacts, and the effects of management, it is both possible and essential for adaptation to proceed using the best available science" (4.4, p. 1–2). While the adaptation report did not offer suggestions exclusive to the West, their proposals were widely applicable to many different ecosystems.

Increasing ecosystem resilience is an existing water management approach that can be adapted to mitigate longer-term climate change (4.4, p. 1–3). Such approaches include protecting key ecosystem features, restoring lost or compromised ecosystems, and using areas less affected by climate change as refuge for climate-sensitive migrants (4.4, p. 1–3). SAP 4.4 suggests that approaches should be based on considerations such as: "the ecosystem management goals, type and degree of climate effects, type and magnitude of ecosystem responses, spatial and temporal scales of ecological and management responses, and social and economic factors" (4.4, p. 1–3).

Reducing anthropogenic stresses is another option that is a widely accepted response to climate change (4.4, p. B–8). Land use change, increased pollution and invasive species are among the many stresses disturbing the natural ecosystem, exacerbating the affects of climate change (4.3, p.3). Human stressors such as deforestation, dam building, urbanization, and agriculture not only harm resources and ecosystems, but also hinder their ability to cope with climate change. The adaptation report suggests "there is very strong scientific data to show that when human stresses are reduced, the systems recover" (4.4, p. B–8).

Conclusion

The latest CCSP synthesis product on resources (SAP 4.3) indicates a trend toward increased temperatures and decreased precipitation across the western U.S., with drought-like conditions likely to continue and worsen. Water management in the West is likely to become more challenging as water becomes more scarce and variable. The report suggests that the first step preparing for and mitigating future changes is assessing the current situation and identifying where improvements within current hydrologic observing systems are needed. They find that "trends toward increased water use efficiency are likely to continue in the coming decades" and suggests that "declining per capita water consumption will help mitigate the impacts of climate change on water resources." A second recent synthesis product, the adaptation report (SAP 4.4), presents subsequent steps including the increase of ecosystem resilience and the decrease of anthropogenic stresses. As the understanding of climate change increases, so will the ability of humans to prevent, mitigate and adapt to future changes.

References

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On the Web

- Full copies of SAP 4.3 and SAP 4.4, as well as other final CCSP products, can be found at: http://www.gcrio.org/library/sap-final-reports.htm.
- For more information about the CCSP, visit: http://www.climatescience.gov.